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US 5413378 A US 5366242 A US 5232243 A

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## (54) Gas pressure regulator for automotive air bag system

(57) An automotive air bag system comprises an air bag unit (1) including a gas generator (3), a folded air bag (4), a case (2) containing the gas generator and the air bag. The system is provided with a pressure relief hole (6); a lid (5) covering an open upper end of the case, a valve (7) combined with the pressure relief opening, an actuator (8) for operating the valve, a temperature sensor (10) for measuring the temperature of an environment around the air bag unit, a sitting position detector (12) for detecting a sitting position of the passenger, and a controller (9) for controlling the operation of the actuator according to temperature signal from the temperature sensor and sitting position signal from the sitting position detector. The opening degree of the pressure relief opening is adjusted to a desired degree according to the temperature of the environment around the air bag unit and the sitting position of the passenger relative to the air bag unit whereby the air bag is inflated at a normal internal pressure and may not be inflated with excessively great force regardless of the temperature of the environment around the air bag unit.

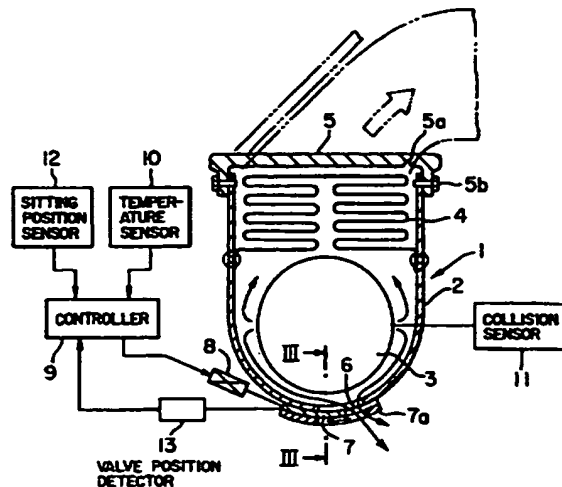


FIG. 2

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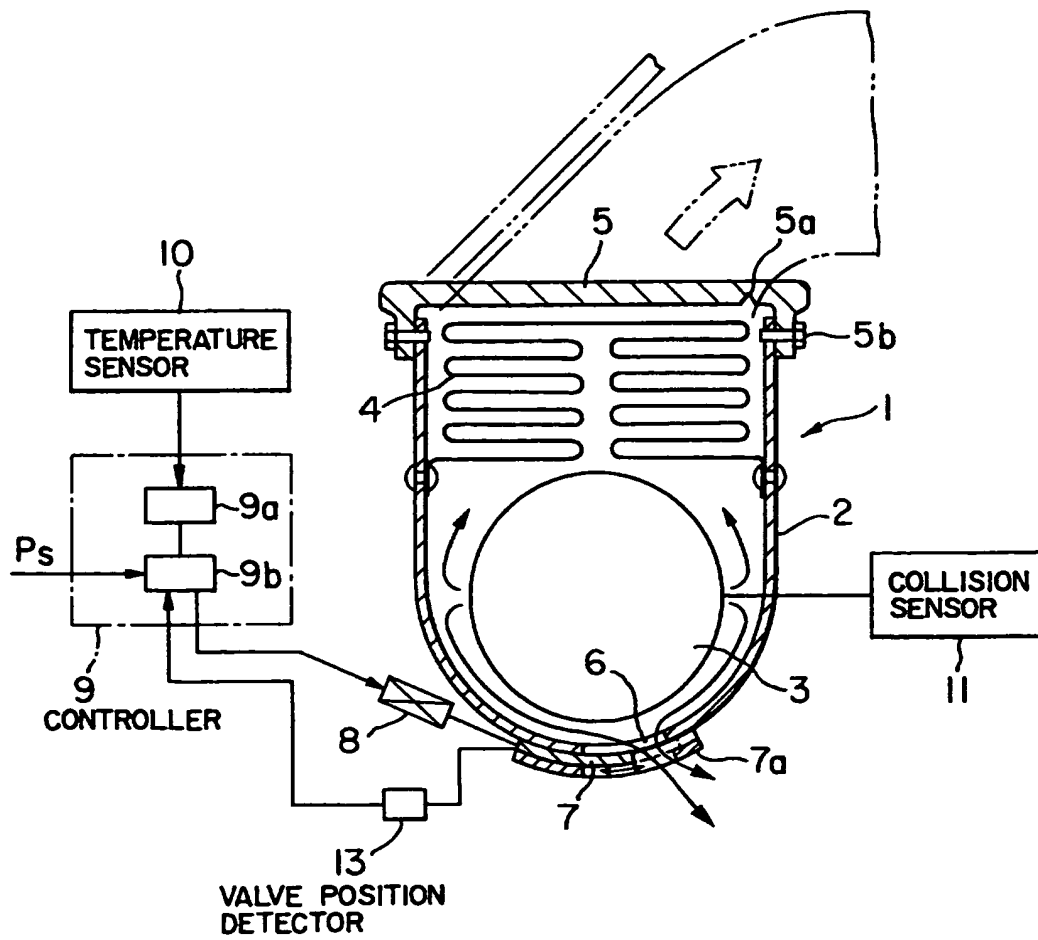


FIG. 1

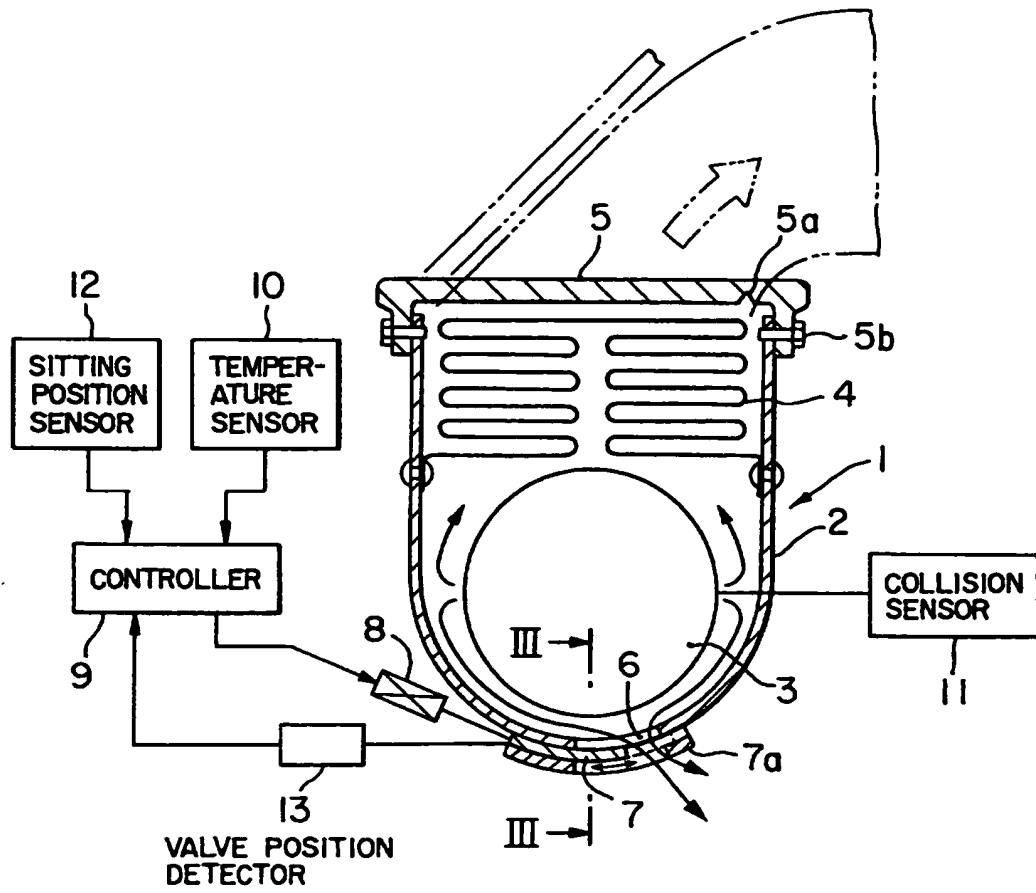


FIG. 2

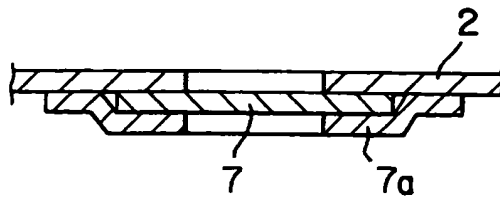


FIG. 3

## GAS PRESSURE REGULATOR FOR AUTOMOTIVE AIR BAG SYSTEM

5       The present invention relates to an automotive air bag system and more particularly to a gas pressure regulating device for an automotive air bag system.

10       Various automotive air bag systems have been developed as safety measures to prevent the passenger from collision with an interior of the vehicle when a vehicle collides against an obstacle. The automotive air bag system generally has a gas generator which generates a gas to inflate an air bag upon collision of a vehicle in order  
15       that the inflated air bag receives the upper part of the passenger's body including the head when the passenger's upper body part is forced to move forward upon the collision of the vehicle against an obstacle. The pressure of the gas generated by the gas generator in the air bag is  
20       dependent on the ambient temperature. Therefore, it is possible that the pressure of the gas in the inflated air bag rises excessively to damage portions around the air bag system, to brake the air bag itself if the temperature of the passenger's compartment in which the air bag system is  
25       installed is extraordinarily high.

      Measures to prevent such a problem have been proposed in, for example, JP-U Nos. 6-1029 and 5-86721. A prior art automotive air bag system incorporating one of those measures has a case containing a gas generator and a folded  
30       air bag, and provided with an opening, and a resin plate covering the opening of the case and having a safety portion which breaks when a pressure exceeding a threshold pressure acts thereon. When the pressure of the gas in the case rises excessively, the safety portion breaks to open  
35       the opening so that the gas is discharged from within the case to reduce the pressure of the gas in the case. Another prior art automotive air bag system incorporating

another one of those measures has an air bag having a gas discharge port and a sealed portion provided with a joint which breaks when the pressure of the gas in the air bag increases beyond a predetermined pressure.

5        In any one of those prior art automotive air bag systems, the relatively easily breakable portion breaks, when an excessively high gas pressure acts thereon, to reduce the pressure of the gas in the air bag. The operating gas pressure in the air bag is liable to be  
10       affected by the breaking strength of the relatively easily breakable portions, which is difficult to adjust to a fixed value. For this reason it is difficult to form a relatively easily breakable portion of a breaking strength which provides a predetermined gas pressure, and the area  
15       of the opening through which to discharge the gas to reduce the gas pressure is very difficult to be controlled reliably.

         Accordingly, it is an aim of embodiments of the present invention  
20       to provide an automotive air bag system capable of inflating an air bag at an internal pressure within a predetermined pressure range regardless of the temperature of the environment surrounding the automotive air bag system so that the air bag may not excessively rapidly  
25       inflated at an excessively high internal pressure, and the air bag may not damage parts around the automotive air bag system and may itself not break.

         According to the present invention, an automotive air bag system comprises a gas generator, a folded air bag, a  
30       case for containing the gas generator and the air bag, and a lid covering an open end of the case. In this automotive air bag system, the case is provided with a pressure relief opening to discharge a gas generated by the gas generator from the case, the opening degree of the pressure relief  
35       opening is adjusted by a valve, the valve is operated by an actuator, and a controller controls the actuator responsive to a temperature signal provided by a temperature sensor

for measuring the temperature of a passenger compartment or a sitting position signal provided by a sitting position detector for detecting the position of the upper body part of a passenger seated on a seat to adjust the opening degree of the pressure relief opening.

Since the controller controls the actuator according to the temperature signal provided by the temperature sensor and/or the sitting position signal provided by the sitting position detector for detecting the position of the upper body part of a passenger seated on the seat to adjust the opening degree of the pressure relief opening, the pressure of a gas generated by the gas generator is controlled properly. Therefore the air bag takes the passenger's upper body half gently and so the air bag may not be excessively rapidly inflated at an excessively high internal pressure.

Preferred embodiments of the present invention will be understood from the following detailed description referring to the accompanying drawings.

Fig. 1 is a schematic sectional view of an automotive air bag system in a first embodiment according to the present invention;

Fig. 2 is a schematic sectional view of an automotive air bag system in a second embodiment according to the present invention; and

Fig. 3 is a sectional view along III-III in Fig. 2.

Referring to Fig. 1, an automotive air bag system in a first embodiment according to the present invention has an air bag unit 1 including a case 2. The case 2 has a U-shaped section opening upward and provided with a pressure relief hole 6. A gas generator 3 is contained in the case 2, and an air bag 4 is provided in a folded state within the case 2. A lid 5 covers the open upper end of the case 2. A valve 7 is slidably supported on the case 2 by guide members 7a to adjust the opening degree of the

pressure relief hole or opening 6, and an actuator 8 is provided for moving the valve 7. A valve position detector 13 detects the opening degree of the valve 7. A controller 9 responds to the valve position detector 13 and controls the actuator 8 in a suitable position, and a temperature sensor 10 measures the temperature of an environment surrounding the air bag unit 1 and supplies a temperature signal to the controller 9.

The air bag unit 1 of the automotive air bag system is disposed in a central portion of the steering wheel of a vehicle when the automotive air bag system is used for protecting a driver, or the air bag unit 1 is disposed in a portion of an instrument panel in front of a passenger seat beside the driver's seat. Upon collision of the vehicle against an obstacle, a collision sensor 11 provides a gas generator actuating signal to actuate the gas generator 3. Then, the gas generator 3 generates a gas to inflate the air bag 4. The air bag 4 is inflated by the gas generated by the gas generator 3 to open the lid 5 forcibly, and the inflated air bag 4 receives the upper part of the body of the driver (passenger) and his (or her) head forced to move forward. The lid 5 is provided with a breaking portion 5a which breaks when a pressure is applied to the lid 5 by the inflating air bag 4. When the breaking portion 5a of the lid 5 is broken, the lid 5 is turned upward and forward on its front edge to open. The lid 5 may be released by any suitable conventional means. For example, the lid 5 may be held at a closed position on the case 2 by shear pins 5b which are broken at a predetermined shearing force.

The operation of the actuator 8 for operating the valve 7 to adjust the opening of the pressure relief opening 6 is controlled by output signal from the controller 9. The temperature sensor 10 is placed so as to measure the temperature of a region of the passenger compartment around the air bag unit 1. The controller 9 estimates or

calculates in a calculator 9a a gas pressure  $P_A$  of a gas generated by the gas generator 3 on the basis of the temperature measured by the temperature sensor 10. The controller 9 then compares the calculated gas pressure  $P_A$  with a set gas pressure  $P_s$  in a comparator 9b, determines an opening degree of the pressure relief opening 6 necessary to reduce the gas pressure  $P_A$  by the difference ( $P_A - P_s$ ) if  $P_A > P_s$  and generates a control signal to operate the valve 7 by the actuator 8 so that the opening of the pressure relief opening 6 is adjusted to a desired opening.

Usually, the gas generator 3 generates a gas necessary for inflating the air bag 4 at a predetermined inflating rate to an internal pressure suitable for safely receiving the upper part of the body of the driver (passenger) which moves forward upon collision of the vehicle with an obstacle. The pressure of the gas generated by the gas generator 3 increases with increase of the temperature of the region around the gas generator 3. If the gas pressure is too high, it is possible that the air bag 4 is inflated with great force to break the air bag 4 itself. Therefore, the gas pressure  $P_A$  is estimated on the basis of the temperature measured by the temperature sensor 10, the estimated gas pressure  $P_A$  is compared with the set pressure  $P_s$ , i.e., an upper limit pressure of a normal gas pressure range, and the actuator 8 is controlled so as to adjust the opening degree of the pressure relief opening 6 to an appropriate degree according to the measured temperature if  $P_A > P_s$ . Thus, the opening degree of the pressure relief opening 6 is adjusted to an appropriate degree in a range from a fully open state to a fully closed state according to the measured temperature. Therefore, the gas pressure for inflating the air bag 4 is controlled to be in the normal pressure range regardless of the temperature of the environment in which the gas generator 3 generates the gas,



and the air bag 4 will not be inflated with excessively great force. Consequently, the air bag 4 will not break.

Referring to Fig. 2, in which like or corresponding parts to those shown in Fig. 1 are designated by the same reference characters, an automotive air bag system in a second embodiment according to the present invention is substantially the same in configuration as the system of Fig. 1, except that the second embodiment is further provided with a sitting position detector 12. In the automotive air bag system shown in Fig. 2, a controller 9 determines a desired opening degree of the pressure relief opening 6 on the basis of a temperature represented by a signal provided by a temperature sensor 10 and a position of the upper part of the driver's (passenger's) body represented by a signal provided by the sitting position detector 12. The controller 9 responds to the valve position detector 13 and operates an actuator 8 to adjust the opening degree of the pressure relief opening 6 to a desired degree by a valve 7.

The sitting position detector 12 may be a radar, an ultrasonic distance finder, an image recognizing device or the like. The sitting position detector 11 detects the position of the upper body part including the head of the driver (passenger) seated on the seat and gives a position signal representing the position of the driver's (passenger's) upper body part, to the controller 9. The controller 9 determines the positional relation between the driver (passenger) and the air bag unit 1 of the automotive air bag system disposed in front of him (her) on the basis of the position signal. The controller 9 operates the actuator 8 to open the pressure relief opening 6 in a relatively large opening degree as the position of the driver (passenger) approaches the air bag unit 1 relative to a set sitting position to increase the discharge of the gas generated by the gas generator 3 so that the air bag 4 is not inflated with very great force and the inflated air bag 4 is able to gently receive the driver (passenger)

moving forward.

The operation of the controller 9 for adjusting the opening degree of the pressure relief opening 6 on the basis of the output signal of the temperature sensor 10 is the same as that of the controller 9 of the system shown in Fig. 1.

Since the opening degree of the pressure relief opening 6 is adjusted according to both the temperature of the region around the air bag unit 1 measured by the temperature sensor 10 and the position of the driver (passenger) relative to the air bag unit 1 determined by the sitting position detector 11, the gas pressure for inflating the air bag 4 is in the normal pressure range regardless of the temperature of the environment in which the gas generator 3 generates the gas, and therefore the air bag 4 will not be inflated with excessively great force to break the air bag 4. The pressure of the gas for inflating the air bag 4 is additionally controlled properly according to the driver's (passenger's) sitting position relative to the air bag unit 1 whereby the inflated air bag 4 can gently receive the upper part of the driver's (passenger's) body moving forward and hence the air bag 4 will not be inflated with excessively great force to press back the driver (passenger).

The valve 7 is supported slidably by guide members 7a extended along the side edges of the pressure relief opening 6, the position of the valve 7 relative to the pressure relief opening 6 is detected by a valve position detector 13, and the controller 9 operates the actuator on the basis of the output signal of the valve position detector to position the valve 7 so that the opening degree of the pressure relief opening 6 can be adjusted to a desired degree.

While the presently preferred embodiments of the present invention have been shown and described, it is to be understood that these disclosures are for the purpose of illustration and that various changes and modifications may

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be without departing from the scope of the invention as set forth in the appended claims.

CLAIMS:

1. An automotive air bag system for protecting a passenger from collision with an interior of a vehicle having an air bag unit providing a gas generator for generating a gas upon collision of the vehicle with an obstacle, a folded air bag provided to be inflated by the gas generated by the gas generator, a case containing the gas generator and the folded air bag and a lid covering an open end of the case, comprising:

a pressure relief opening provided on the case to discharge part of the gas generated by the gas generator;

a valve combined with the pressure relief opening provided on the case to adjust an opening degree of the pressure relief opening;

an actuator for operating the valve to adjust the opening degree of the pressure relief opening;

a temperature sensor responsive to a temperature of an environment around the air bag unit for providing a temperature signal representing the temperature of the environment around the air bag unit; and

a controller responsive to the temperature signal provided by the temperature sensor for controlling an operation of the actuator to adjust the opening degree of the pressure relief opening to a desired degree according to the temperature.

2. The automotive air bag system according to claim 1, wherein:

said controller comprises a calculator responsive to the temperature signal for calculating an estimated gas pressure, and a comparator for comparing the estimated gas pressure with a set gas pressure to issue a signal for determining an opening degree of the pressure relief opening.

3. The automotive air bag system according to claim 1 or 2, further comprising:

a valve associated with the pressure relief opening to adjust the opening degree of the pressure relief valve.

4. The automotive air bag system according to claim 1, 2 or 3, further comprising:

a sitting position sensor for detecting a sitting position of a passenger relative to the air bag unit and for providing a sitting position signal;

said controller being also responsive to said sitting position signal to adjust the opening degree of the pressure relief opening to a desired opening degree.

5. The automotive air bag system according to claim 4, wherein:

said controller operates to increase the opening degree of the pressure relief opening as a detected sitting position determined by the sitting position signal approaches the air bag unit relative to a set sitting position.

6. An automotive air bag system for protecting a passenger from collision with an interior of a vehicle having an air bag unit providing a gas generator for generating a gas upon collision of the vehicle with an obstacle, a folded air bag provided to be inflated by the gas generated by the gas generator, a case containing the gas generator and the folded air bag and a lid covering an open end of the case, comprising:

a pressure relief opening provided on the case to discharge part of the gas generated by the gas generator;

a valve combined with the pressure relief opening provided on the case to adjust an opening degree of the pressure relief opening;

an actuator for operating the valve to adjust the opening degree of the pressure relief opening;

a sitting position sensor for detecting a sitting position of a passenger relative to the air bag unit and for providing a sitting position signal;

a controller responsive to said sitting position signal to

adjust the opening degree of the pressure relief opening to a desired opening degree.

7. An automotive air bag system substantially as hereinbefore described with reference and/or as shown in Figure 1 or Figures 2 and 3.



# The Patent Office

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Application No: GB 9714067.7  
Claims searched: 1 to 6

Examiner: Karl Whitfield  
Date of search: 19 September 1997

## Patents Act 1977 Search Report under Section 17

### Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.O): B7B (BSB)

Int Cl (Ed.6): B60R 21/00, 21/16, 21/26, 21/28

Other: Online database: Derwent World Patents Index accessed via Questel

### Documents considered to be relevant:

| Category | Identity of document and relevant passage            | Relevant to claims |
|----------|--|--------------------|
| X        | US 5413378 (STEFFENS Jr. et al.) especially figure 1 | 6                  |
| X        | US 5366242 (FAIGLE et al.) especially figs 8-10      | 1-6                |
| X        | US 5232243 (BLACKBURN et al.) especially figure 9    | 6                  |

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|---|--|
| X Document indicating lack of novelty or inventive step   | A Document indicating technological background and/or state of the art.  |
| Y Document indicating lack of inventive step if combined with one or more other documents of same category. | P Document published on or after the declared priority date but before the filing date of this invention.          |
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